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Spruce Budworms
Program

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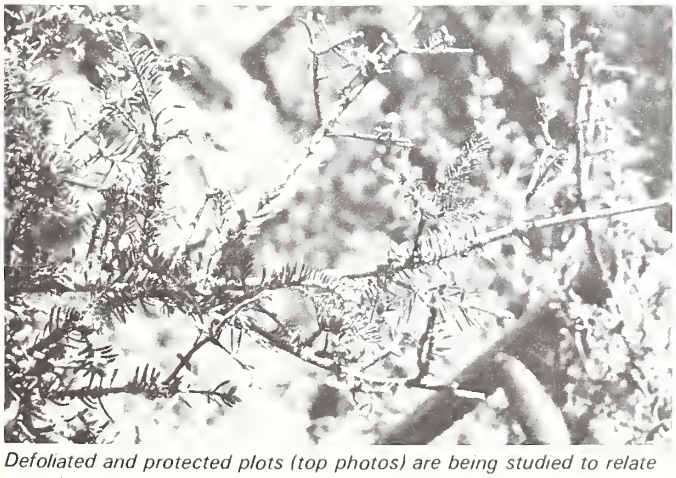
Effects of Spruce Budworm Caused Defoliation On The Growth Of Balsam Fir

Forest managers must be able to predict accurately wood production of different stand types in order to allocate harvesting for a sustained yield. When it is forecast that the forest resource will be in short supply, as it will be for some provinces in eastern Canada, the precision of wood supply predictions becomes very important. The manager must have reliable information about growth rates of forests and the effects on growth of external influences such as budworm defoliation. However, few data presently exist to quantify the loss of wood production. Past studies of the effects of defoliation on the growth of host trees have generally lacked detail and often considered only growth loss at breast height. Attempts to relate this to some gross measure of defoliation (e.g., a light-moderate-severe scale) have not been very successful, and the need for more comprehensive studies of defoliation and growth loss has been recognized by both forest managers and researchers for several years.

A severe budworm outbreak that began in the mid-1970s on Cape Breton Island, N.S., has provided an opportunity to learn more about defoliation-caused growth loss. The study began in 1976-77 on the Cape Breton Highlands and is being carried out by Drs. Harald Piene and Dave MacLean of the Maritimes Forest Research Centre, with the cooperation of several other researchers. The main objective is to relate detailed defoliation estimates of 25- to 30-year-old fir trees to growth determined by stem analysis.

The study incorporated these steps designed to eliminate the shortcomings of several earlier studies:

1. The study was begun in the 1st year of budworm feeding; failure to ascertain the initial year of feeding or starting a study after several years of unmeasured defoliation caused problems in the past.



Defoliated and protected plots (top photos) are being studied to relate growth loss to defoliation of balsam fir trees on the Cape Breton Highlands. Sample branches from trees in each of the plots are shown below.

2. It was decided to establish undefoliated check plots in the immediate area of the defoliated plots so that growth of defoliated and undefoliated trees could be directly compared. This was accomplished by an intensive, closely controlled, annual spraying of insecticide in the control plots.
3. A detailed, nondestructive assessment of defoliation on the same trees in the plot was conducted each year. Thus, growth of the trees would not be disturbed by removal of branches for defoliation or insect population level sampling, and yet, an accurate record of defoliation each year on each tree could be maintained. A record of tree growth is maintained in the annual rings; this tree growth can be measured at the end of the outbreak.
4. Defoliation was measured not only for the current age class of needles on the sample trees, but for all age classes, each year. Thus, increases in defoliation of older age classes of needles in successive years could be attributed to backfeeding.

In addition to examining growth loss from defoliation, the investigators looked at the rate and amount of recovery of growth that could be expected if protection (insecticide spraying) was applied after several years of defoliation.

Eight 0.25-ha (0.63-acre) plots were established, four each in adjacent spaced and unspaced forest stands. Each year from 1977 to 1981, four plots (two spaced and two unspaced) were sprayed from the ground to protect the trees from budworm defoliation. These plots will be sprayed annually throughout the experimental period. In addition, two recovery plots were established, one in 1977 and one in 1980, to study the recovery of tree growth after different sequences of defoliation and protection.

Some of the methods used in the study are as follows: Detailed annual assessments of feeding on each age class of needles were carried out for a subset of the trees in each plot. Defoliation for a given year was estimated in the spring of the following year, prior to insect feeding (i.e., 1976 defoliation was estimated in the spring of 1977). Scaffolding was set up adjacent to each sample tree, and one branch was selected from each whorl, starting at the top and proceeding in a spiralling fashion down the tree to the 13th or 14th whorl on the spaced trees or the 10th or 11th whorl on the unspaced trees. Total length and width of the sample branches were measured, and the number of buds was recorded each year. Defoliation was also estimated on these sample branches each year. The second-order branches within each sample branch were used as discrete sampling units. Within each secondary branch, all shoots of each age class of needles were individually rated for defoliation using eight classes; that is, all of the shoots in the current age class of needles, the 1-year-old class, and all other age classes present on the branch were individually tallied by defoliation class each year.

Based on analysis of defoliation data collected between 1977 and 1979, the sampling effort in 1980 and 1981 was decreased and defoliation was estimated only on every second branch. In addition to the detailed data collected from a subset of trees in each plot, basic mensurational data were collected from each tree in the plot including d.b.h., height, crown length, crown width, top condition, length of bare top, and mortality. Starting in 1980, all trees in the unprotected plots were rated visually (by use of binoculars) for total and current defoliation.

In 1976, 1977, and 1978, current defoliation in the unprotected plots was nearly 100 percent, but in 1979 the budworm population dropped and current defoliation ranged from 70 to 90 percent. As a result of prolific shoot production by the defoliated trees in 1979, foliage remaining on the trees could not be estimated accurately from comparisons with the protected trees, and a method for nondestructive estimation of the foliage biomass by age class on standing fir trees was required. A method was derived from the analysis of interrelationships among needle weight, needle length, number of needles per centimetre of shoot, and shoot length of fir shoots. Needle weight was found to be a function of mean needle length, while the number of needles per centimetre of shoot was found to be related to the reciprocal of needle length. These two relationships were combined so that weight of needles per shoot could be predicted from data on mean needle length and mean shoot length for the branch.

In addition to yearly defoliation and biomass estimations in the plots, insect populations are monitored yearly, and nutritional and physiological changes in foliage from defoliated trees are being noted, as well as morphological changes in needles, which are being studied by Kevin Percy of the Maritimes Forest Research Centre. Attempts are also being made to monitor physiological stress caused by defoliation, by use of a Shigometer that measures electrical resistance in the cambium. This study was initiated in 1979 and is under the direction of Dr. D.S. Fensom of Mount Allison University, Sackville, N.B. Dr. Ron Wall, of the Maritimes Forest Research Centre, is monitoring secondary insects and diseases yearly from several trees cut outside the defoliated plots.

Spruce budworm populations in the study area were still high in 1980 but decreased somewhat in 1981, the 6th year of defoliation. The study of growth loss will continue until the population subsides, and the recovery growth plots will be followed until the trees have regained predefoliation growth rates.

The main objectives of the present study on an individual tree and on an individual stand basis are:
1. To relate a known decrease in foliar biomass on spaced and unspaced balsam fir trees, caused by defoliation, to a reduction in volume growth for each year and/or a sequence of years in the study period.
2. To relate the loss in foliar biomass over time to the onset of secondary insect attack and decay.
3. To relate the defoliation history or the loss in foliar biomass to the subsequent production of new foliage.

4. To determine the time required for balsam fir trees with different defoliation histories to recover to predefoliation growth rates (stem and foliar biomass) when foliage protection (spraying) is applied.
5. To determine if a relationship exists between stem growth rate and foliar biomass production in stressed trees.
6. To define intra- and inter-tree variance in stem and foliar biomass growth and develop a sampling technique to measure these variables.
7. To determine if the detailed methods of this study can be compressed into a broad-scale survey tool, assuming that a measure of the foliar biomass remaining on the tree after attack is the best prediction of the fate of the tree.

For those interested in more details of this study, a publication "Effects of spruce budworm caused defoliation on the growth of balsam fir — experimental design and methodology," Information Report M-X-128, was recently printed by the Maritimes Forest Research Centre, P.O. Box 4000, Fredericton, N.B. E3B 5P7.

Harald Piene and David A. MacLean — Research Scientists
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Silvicultural Practices To Minimize Spruce Budworm Impact

International Paper Company (IP) and Canadian International Paper Company (CIP) own or have harvesting rights on approximately 6 070 400 ha (15 million acres) of forest resources under continual threat from the spruce budworm. In an attempt to deal with this threat, IP initiated a large-scale research and demonstration project to evaluate the long-term effect of certain silvicultural practices that might minimize budworm impact. This is a joint research project of IP and CIP that has received some funds through Forest Pest Management (USDA Forest Service) and CANUSA demonstration projects.

In northern Maine, this project is located on IP's lands in Township 11-Range 11(T11-R11) and Township 11-Range 12 (T11-R12). In Canada, the project sites are on the Miramichi Lumber Company's freehold 80.5 km (50 mi) north of Fredericton and on CIP's freehold in the Gaspé region of Quebec.

The major objectives of this project are to (1) establish silvicultural systems compatible with future forest management practices that might reduce forest vulnerability and susceptibility to the budworm, and (2) evaluate the long-term effects of these silvicultural treatments on budworm impact in treated and adjacent stands.

In Maine, IP initiated two silvicultural treatments, a clearcut and a fir-reduction cut. Each treatment was initiated on two 81-ha (200-acre) tracts of land, with one treatment located in each township. The primary objective of the clearcut treatment was to change stand composition by replanting the area with species less susceptible to the budworm, as well as with species that would provide good growth, yield, and product quality over the next rotation. The fir-reduction cut was chosen to demonstrate a method of natural stand management considered by many to be effective in reducing budworm impact in the residual stand. All fir, merchantable and nonmerchantable, was removed from the stand.

Sites were chosen for the project in the summer of 1979, and work commenced on the operational component of the project. To initiate the clearcut treatment, a normal harvesting operation was begun on the sites in the fall of 1979. After harvesting and prior to planting, the slash and already established competing vegetation were reduced to make the site more traversable for hand planting.

Site preparation consisted of a chop and a burn. Both sites were chopped with a Marden drum chopper; the T11-R11 site was chopped in the winter on frozen ground with a D7 tractor, and the T11-R12 area was chopped in July 1980 with a D8 tractor. This chopping broke up the slash on the ground and split the stumps and old logs. Since a great deal of logging debris and herbaceous competition that would hinder hand-planting remained, both areas were burned with a helitorch in August 1980. This was the first large-scale prescribed burn on IP lands in Maine, and it was very successful. Since conditions at the sites were different, the burns were not entirely uniform. A 40 percent burn was achieved on T11-R12 and a 60 percent burn on T11-R11.

Reforestation of the sites was done in May 1981, when both areas were planted by a contract planting crew to jack pine, white pine, black spruce, white spruce, and Japanese larch. All seedlings used on the sites were grown as containerized stock at CIP's greenhouses in Dalhousie, N.B. Trees were planted in numbers of 1 551/ha (622/acre), at a spacing of 2 m by 3 m (7 by 10 ft). Each study area was divided into 10 operational blocks of 8 ha (20 acres), and each species was planted on two blocks at each site. The species were assigned to specific blocks in an attempt to achieve stand diversity, as well as to expose each species to a variety of site conditions. Within each 81-ha (200-acre) planting, nine research blocks where all five species were planted in complete randomized blocks were established to monitor tree growth and impact. To maximize the information obtained, research blocks were placed on different site conditions within each area.

In the fir-reduction cuts, a contractor harvested all fir 2.5 cm (1 in.) or more d.b.h. All merchantable and sapling-size fir was removed in one operation. The fir-reduction cut on T11-R12 was in the winter of 1979-1980 and the cut on T11-R11 in the winter of 1980-1981. To ensure that a stand would exist after harvest, it was essential that the fir-reduction treatments be done on sites in which spruce constituted a substantial proportion of the existing stand. On both cuts, stocking on the site was reduced by approximately half. The only spruce or hardwoods removed from the site were those cut in the clearing of skid trails and haul roads. Because of stocking differences on the sites, the final residual stands differed. On the T11-R11 cut, 92.25 m^3 (stacked)/ha (10.3 cords/acre) remain with 62.7 m^3 (stacked)/ha (7 cords/acre) spruce. On the T11-R12 cut 143.3 m^3 (stacked)/ha (16 cords/acre) were left with spruce accounting for 123.6 m^3 (stacked)/ha (13.8 cords/acre). The only fir left on either site was less than 1.3 cm (0.5 in.) d.b.h.

In Canada, the two treatments chosen for this study were a commercially clearcut area left to regenerate naturally and a commercially clearcut area replanted to species less susceptible to the budworm. Both treatments were integrated into the normal operations at each CIP location. The study sites were then marked and made accessible for the study.

In New Brunswick, two sites on the freehold were chosen for the study, the Napadogan and Juniper cuts. Prior to harvesting, the Napadogan site was a forest composed primarily of sugar maple, beech, red spruce, and balsam fir — the result of past harvesting practices. The area was harvested between 1976 and 1978 with a feller buncher and feller forwarder and replanted to jack pine, 129 ha (319 acres); black spruce, 77 ha (190 acres); and red spruce, 15 ha (37 acres). The planting stock was container stock from CIP's greenhouses in Dalhousie, N.B. Approximately 20 ha (50 acres) were left unplanted at the site for the natural regeneration treatment.

The conditions at the Juniper study site differed from those at the Napadogan site: prior to treatment, the Juniper stand consisted primarily of conifers and some mixed wood stands. The area was harvested as a tree-length cut and skid operation in 1979 and scarified immediately. This site was replanted to jack pine, 67 ha (166 acres); and black spruce, 65 ha (161 acres); using containerized stock from CIP's greenhouses in Dalhousie. For natural regeneration treatment, a 40.5-ha (100-acre) band running north and south was left unplanted in the middle of the area.

Two study locations, the Lac Simoneau and Trout Creek areas, were chosen for the Quebec portion of the study. Both areas are located on CIP's freehold in the Gaspé that lies between the St. Lawrence River and Chaleur Bay, due north of Campbellton, N.B. Prior to treatment, both study areas consisted primarily of balsam fir in pure or mixed stands with black spruce and/or intolerant hardwoods. Both sites were harvested with Koehring shortwood harvesters and scarified with a D7 Caterpillar with barrels and chains. The Lac Simoneau site was planted to jack pine, 38 ha (94 acres), and black spruce, 89 ha (220 acres), in the summer of 1979. The Trout Creek site was planted to black spruce, 65 ha (161 acres) in 1978 and 125 ha (309 acres) in 1979. Approximately 20 ha (50 acres) were left unplanted at both sites for the second treatment. All seedlings were containerized stock from CIP's Dalhousie greenhouses.

To monitor the influene of these treatments on the long-term vulnerability and susceptibility of the forest to the budworm, a series of 294 permanent 0.04-ha (0.1-acre) plots have been established. Information about these plots includes all facets of tree growth and impact from possible damaging agents, as well as information on the changes in stand composition resulting from these treatments. Data have been collected from these plots for one to three field seasons depending on the location.

Officials of IP recognize that a project such as this is a long-term venture. The company plans to monitor these study plots throughout the stand rotation to ascertain the long-term effect of manipulating the forest's species mix to minimize budworm impact.

Suzanne E. Goldman — International Paper Company
Bangor, Maine

JPU Meets in Fredericton

Members of CANUSA's Joint Planning Unit (JPU) met for their annual conference July 28-30 in Fredericton, N.B. Hosting the event were Murray Neilson (JPU cochairman) of the Maritimes Forest Research Centre and H.J. (Bud) Irving, of Forest Protection Ltd. (FPL). The session included an interesting tour of FPL operations on July 29.

Members discussed for some time the question of the need for outside evaluation of the CANUSA program. It was proposed that a committee of three — Ken Stratton, Jay Hughes, and Tom Sterner — be appointed to examine the evaluation issue.

Among "old business" items, the human health aspects of budworm control operations came up for review. The program's position remains the same: CANUSA expresses interest in this subject and supports the need for human health research on pesticides.

Responding in part to the Eastern Spruce Budworm Council's queries, Chuck Buckner reviewed for the JPU the status of aerial application technology investigations funded by CANUSA. In general, committee members agreed some basic research still needs to be done in this area. The JPU recommended that all agencies responsible for research and development in application technology be alerted to its importance as a management tool and be encouraged to increase their efforts.

At this time, an agreement is being negotiated by the United States Department of Agriculture, the Environmental Protection Agency, the Federal Aviation Authority and the National Aeronautics and Space Administration to develop aerial application technologies to satisfy long-range needs.

Figure 1. Members of the Joint Planning Unit and guests listen to Chuck Buckner's discussion of aerial spray application technology.

Newsletter content, and particularly the annual spruce budworm infestation report, came up for discussion next. Annually, in March, the newsletter has printed a summary of infestation statistics for the previous year. It was not possible to collect these data for 1980. However, with the cooperation of Jim Stewart's staff at the USDA Forest Service in Washington and Tom Sterner and colleagues at the Canadian Forest Service in Ottawa, the statistics on 1981 outbreaks should be available later this year and be ready for publication early in 1982.

The JPU considered and approved the Transition Plan — the document that lists anticipated final program outputs and phasedown efforts.

Unit members endorsed a documentation plan proposed by Janet Searcy and Mel McKnight. The plan "for scientific, technical, and popular documentation" of program results, was requested by the JPPC.

The Searcy-McKnight presentation involved two publications. The first — a 25-page softcover brochure with color photographs and minimal, nontechnical text — will be a final accomplishments report. It will chronicle the achievements of the program and will be meant for distribution to a nonscientific readership.

The second publication will be proceedings of a symposium on the spruce budworms. Talks presenting new knowledge on budworm biology, ecology, and control will be featured during the symposium, to be attended by scientists from Canada and the United States. The proceedings publication will contain, in addition to the papers on these talks, contributed papers on specific scientific studies.

The 1982 JPU meeting will be held Aug. 16 and 17 at Sault Ste. Marie, immediately before the JPPC meeting at the same location.

At the end of the 3-day meeting, Heather and Murray Neilson entertained the group, providing the venue for a CFS-hosted lobster dinner and social evening. In addition to JPU members, guests included Mr. and Mrs. Bud Irving, Dr. and Mrs. F.E. Webb, and Mr. and Mrs. E.G. Kettela.

A report of the 1981 meeting was prepared by cochairmen Murray Neilson and Gerald Anderson for submission to the JPPC meeting on August 25-26 in St. Paul, Minn.

Spraying With Forest Protection Ltd. In New Brunswick

This year's field trip took Joint Planning Unit (JPU) conferees to the headquarters of Forest Protection Ltd. (FPL) in Fredericton for a brief look at this private corporation that conducts aerial spraying against spruce budworm throughout the province. Bud Irving, who worked for the company in 1953, and is now Managing Director, provided background information on the equipment and technology used by his spray teams. Members of the JPU then went across the street to the airstrip, where they examined FPL's fleet of Grumman TBM Avengers. These folding-wing planes require just 7 minutes for refueling and reloading of the spray tank between flights. The Avenger is flown at 240 km/h (170 mph) 30-45 m (100-150 ft) above the forest canopy.

Figure 2. Bud Irving shows members of the JPU where his company, Forest Protection Ltd., sprayed in New Brunswick last year.

Since these ex-military planes are no longer in production, FPL maintains a stockpile of parts and contracts annually with a local firm to provide mechanical servicing on the site. Bud's walking tour included a short stop at the parts warehouse.

Bud emphasized the importance of having experienced pilots. Many of FPL's crews are former military pilots, and all have commercial licenses. The younger and less experienced pilots generally fly the Cessna-class guideplanes that precede the Avengers. A prospective spray plane pilot is given an FPL-designed training course starting with instruction on the Harvard aircraft. The Harvard was used as a pilot trainer during the Second World War. Once the prospective pilot masters the Harvard, he then receives instruction in the spray plane. The 17-hour course covers formation flying, spray runs, and flying with the aircraft carrying a half payload and later a full payload.

FPL recognizes that safe handling of insecticide requires not only experienced pilots but ground crews and management who think "Safety First." When the 205-L (45-gal) drums of fenitrothion in use this year arrive at the industrial park in Fredericton, they are stacked three high with wooden planks between them to distribute the weight load. During unloading, a supply of decontaminants is nearby. In the warehouse, respirators, fire extinguishers, and safety clothes are readily available, in case a leaky drum is discovered.

Protection of ground-crew personnel is important at FPL. Mixers and loaders must wear oilskin overalls and jackets, bump caps, steel-toed shoes, neoprene boots, rubber gloves, and goggles. Mixers must also wear respirators or inhalators. Fresh water is available at every loading site to hose down any employees who have contacted the insecticide and to decontaminate the site itself. Fire extinguishers are at all work locations, both in the buildings and at all of FPL's airstrips.

At the Juniper (home) base, a helicopter is warmed up and ready to help locate planes that are in trouble or downed. When a pilot has to jettison the load for safety purposes, FPL's concerns are the pilot and the plane, then what was spilled, how much, where, and how it is likely to affect humans, animals, and the environment. When an insecticide spill occurs, the affected area is decontaminated with soda ash or lime. If a load is jettisoned, this fact is first relayed to the Fredericton FPL headquarters and then to the various federal and provincial authorities.

In 1981 FPL sprayed 1 880 000 ha (4.7 million acres) of budworm-infested spruce-fir forest in New Brunswick. New Brunswick furnished 71 percent of FPL's $13 million budget this year, and the timber companies owning lands that were sprayed furnished the rest. In 1981 these monies supported 83 aircraft, 44 of which were spray planes. FPL employed 408 people this year, with a payroll of $1 200 000. Thirty employees are full-time and work year-round. Most of the seasonal help at the airstrips are local people working during the 2-month spray season as cooks, mechanics' helpers, calibration recorders, and mixers.

FPL is a regional organization and, as much as possible, hires, contracts, and purchases within New Brunswick. A substantial portion of its budget is cycled through the local economy. In addition, FPL finances research relating to aerial application technology and cooperates with scientists in the provincial and federal governments, universities, and industry. Although research outputs are expected primarily to improve FPL's operation, the research partnership expects to provide substantial spin-off for the aerial applicator industry.

Without a doubt, forest protection is expensive in New Brunswick. But it would be a mistake to think of this money as lost. It recirculates locally, providing jobs for Maritimers and supplementing the flow of goods and services while protecting the spruce-fir forest of New Brunswick from budworm for another year.

Janet Searcy — Information Coordinator
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JPPC Meets in St. Paul

The morning of August 25 found members of CANUSA's Joint Policy and Program Council (JPPC) gathered at the North Central Forest Experiment Station in St. Paul, Minn., for their annual meeting. The JPPC discussed management plans for the duration of the program and a proposal to extend it for 2–5 years beyond the scheduled termination date of September 30, 1983.

Members discussed the JPU recommendations to the JPPC on program-management matters. The two groups share the view that CANUSA needs to be evaluated both for its own sake, to guide management in the waning years of the cooperative agreement, and for the benefit of future joint research and development efforts between Canada and the United States. It was decided that evaluation costs of $40 000–$50 000 would be appropriate. The JPPC endorsed the JPU's recommendation to proceed with plans for creating an evaluation methodology, and the JPU will provide the JPPC with feedback at next summer's joint meeting.

Technology transfer also proved to be a topic of interest to council members. In July the JPU considered proposals to publish a final program accomplishments report and proceedings following an international spruce budworms symposium. Both publications received the JPU's endorsement, and after a lively discussion of pros and cons, the JPPC concurred.

The symposium will probably be a week-long convocation of scientists from both countries. The program will feature what has been learned from CANUSA-sponsored research. Final decisions on place and date have not been made. Organizing an international meeting is no small task, and it was suggested that perhaps retired scientists from both nation's forest services could be persuated to offer their expertise to this project.

Every JPPC meeting features an afternoon of presentations by local investigators. This year, researchers of the USDA Forest Service's North Central Forest Experiment Station and Northeastern Area, State, and Private Forestry, spoke about their actively funded studies. Harold Batzer, Nancy Lorimer, Bill Miller, Pete Rush, and Bob Ford made presentations. Bill Mattson, who was absent because he was attending a conference in the Soviet Union, was represented by his graduate students, Noah Koller and Scott Slocum. Steve Sinclair, of the University of Minnesota, also spoke during the afternoon.

Recognizing that all work and no play is just that, the council repaired to the Minnesota Club in downtown Minneapolis for a cocktail party and a delightful dinner. Hosting these festivities were the Minnesota Forest Industries' Information Council and the University of Minnesota respectively.

Looking toward the future, the council considered several money matters. The fiscal year 1982 Plan of Work and Budget were approved without amendment. In discussing transition (phasedown) planning, Mel McKnight proposed that funding for the years beyond 1983 should be directed largely into development and application activities to assure the greatest returns from CANUSA-sponsored research. He envisions a combination of base funds and accelerated program funds extending through the U.S. fiscal year (FY) '88. Cochairman Bob Buckman pointed out that interest in other insect problems, notably gypsy moth and mountain pine beetle, was building. Undoubtedly, factions supporting these research interests will make a strong bid for CANUSA dollars. But Buckman was optimistic about the chances for spruce budworm research money being available from the United States beyond FY '83. Canadian contributions to the program come almost exclusively from base funds, and research on the spruce budworms will continue in Canada at present levels. The JPPC directed the JPU to come up with options for the JPPC to consider on the subject of extending CANUSA.

Next year's combined meeting of the JPU and JPPC will take place the week of August 16 in Sault Ste. Marie, Ont. George Green, Director of the Forest Pest Management Institute, will be the host.

Personalia

Two prominent spruce budworm research scientists at the Maritimes Forest Research Centre, Fredericton, N.B., retired in October. Charlie Miller and Dave Greenbank, whose careers span the years from the late 1940s to 1981, were honored at an informal gathering in the conference room at the centre in late October.

Charlie and Dave were active in the Green River Spruce Budworm Project. Charlie's field of expertise has been in budworm biology and population dynamics. Dave's research involved budworm moth behavior, especially as it is influenced by weather. Both have impressive lists of publications to their credit. MFRC, the CFS, and the budworm scientific community will miss these two active scientists.

The Western Spruce Budworm In B.C.

Survey officers at the Pacific Forest Research Centre report that cool, wet weather during most of last summer is thought to be responsible for a reduction in the budworm population in most areas and the resultant decrease in visible defoliation, usually apparent in late summer.

The area of defoliation in Douglas-fir stands increased to more than 81 000 ha (202 000 acres) in the Vancouver, Kamloops, and Cariboo Forest regions in 1980. Egg counts, supported by counts of infested buds early in the 1981 season, indicated severe defoliation would occur in a number of areas.

However, in the Vancouver Region, current defoliation was not observed in the outbreak area, and only low populations were found in 3 tree beating samples from the Fraser Canyon and East Anderson River area; the highest number being 23 larvae in a sample at Gilt Creek, where severe defoliation had been predicted.

In the Kamloops Region, moderate defoliation averaging 65 percent of the current year's foliage occurred over an estimated 2 000 ha (5 000 acres) from Barnes Lake southeast of Ashcroft, along the access road from Studhorse Creek to Nesbitt Lake, and at Indian Garden Creek. Heavier defoliation, including up to 35 percent of the 1980 foliage, occurred in several 100-ha (250-acre) patches near Barnes Lake and Jimmies Creek and along the Barnes Lake - Indian Garden access road. Visible light defoliation also occurred at Cornwall Mountain and Oregon Jack Creek and in patches of up to 250 ha (625 acres) at Marshall Creek, Stinking Lake near Cache Creek, the McLean-Gallagher lake area, and near the Hat Creek - Highway 12 junction.

Larvae were active near Clinton in the Cariboo Region, where egg counts had indicated continuing severe defoliation. Light defoliation was recorded at the north end of Hart Ridge and along the south end at an elevation of 800-1000 m (2 600-3 250 ft), and moderate along Maiden Creek. A northern extension of the infestation occurred north of Clinton along the Bonaparte River to Chasm Creek. Light defoliation also occurred for about 5 km (8 mi) along Big Bar Creek, east of the Fraser River.

1981 Research: Spruce Budworm Spraying And Birds

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The Maine Department of Conservation, in cooperation with the USDA Forest Service, has undertaken a 5-year spruce budworm suppression program. One element of the program is a spray project.

Since 1970, environmental research has been conducted in conjunction with all spruce budworm spray projects in Maine. Because birds are important components of the spruce-fir ecosystem and are relatively easy to observe, they have been the subject of 20 studies from 1970 to 1981. In addition, spray projects in eastern Canada have funded at least 20 more studies.

Space does not permit a detailed description of these research efforts, nor can I even begin to discuss the numerous studies that have been conducted elsewhere. I can say, however, that while it is certain that some aerial insecticide applications have had significant effects on avian populations, the chemical insecticides which are being applied in 1981 — Sevin-4-Oil and Orthene Forest Spray — have not been implicated at the dosage rates used in Maine.

This year, the Maine Forest Service will spend about $150 000 on environmental research. By the time this article appears, these research projects will be well underway.

Dr. Malcolm Hunter, Jr., of the University of Maine at Orono, has been conducting research for 2 years on the effects of catastrophic food supply depression on the behavior of birds. Since Sevin (carbaryl) does not have acute toxic effects on birds at the registered dosage rates, Dr. Hunter is conducting a three-part study to investigate the consequences of a sudden drastic reduction in food availability to insectivorous birds.

The first part of this project will be to measure the reproductive success of black-capped chickadees. Artificial nest cavities equipped with cameras will document the efforts of the adults to feed the nestlings. In addition, the birds will be weighed and measured to compare growth rates in sprayed and unsprayed areas. An earlier project showed that the chickadees are not adversely affected by the handling.

The next part of the project involves the documentation of warbler foraging niches, and subsequent disruption of these niches after spraying. Many warblers of the spruce-fir forest have developed specialized foraging preferences while on their summer breeding territories, an adaptation that reduced interspecific competition. Last year, Dr. Hunter found that after spraying, many warblers changed their foraging behavior in response to the sudden decline in arboreal arthropods. These changes included a shift from spruce to other tree species, a lowering of the height at which they foraged, and in some cases, abandonment of areas that had been well used before spraying. This year, these observations will be continued and the significance of these changes will be determined.

Figure 3. Jim Ecker of the Center for Natural Areas, in Gardiner, Maine, uses a telescoping pole and mirror device to check a nest of an olive-sided flycatcher in a spruce budworm spray block in northern Maine. Nest checking to determine fledging success was part of a study funded by the Maine Forest Service to determine the effect of orthene forest spray on bird reproduction.
(Photo by Bob Crotty, Maine Department of Conservation.)

The final aspect of Dr. Hunter's research is an attempt to determine the effects of a sudden food shortage on juvenile black ducks. Two broods of imprinted ducklings will be observed and weighed daily. At the same time, Dr. K. Elizabeth Gibbs, also of the University of Maine at Orono, will be monitoring aquatic invertebrate populations. Observations will determine changes in feeding behaviour and differences in growth rates of ducklings on a control pond and on a sprayed pond. Concerns over declining black duck populations make it imperative to know what effect a direct spraying of rearing ponds may have. It must be pointed out that this study examines a worst case situation, i.e., the pond is directly sprayed. In practice, ponds and other bodies of water are surrounded by unsprayed buffer zones which are designed to mitigate the impact on aquatic organisms.

In addition to Dr. Hunter's work with Sevin, the Center for Natural Areas (CNA) of South Gardiner, Maine, will be investigating the effects of Orthene (acephate) on avian reproduction. CNA's field crew will be locating nests in an acephate spray block and in an unsprayed control area. These nests will be monitored before and after spraying to determine if there is a difference in fledging success between the two areas.

The field crew will be looking for two possible effects. First, the altricial nestlings of canopy-inhabiting passerines may be subjected to an acutely toxic dose of insecticide. Weak, and unable to leave the area, they may be more vulnerable than the fully feathered and mobile adults. Secondly, a reduction in food supply may result in starvation of the entire brook since passerines, unlike raptors, do not have a hunting system. These factors could act in combination, and many species, particularly canopy nesters such as the olive-sided flycatcher (*Nuttallornis borealis*), golden-crowned kinglet (*Regulus satrapa*), and several warblers of the genus *Dendroica*, could be affected. In any case, differences in fledging success should be apparent if either effect occurs. CNA will also conduct observations on warbler foraging niches, so that a comparison can be made with Dr. Hunter's work.

In a related study, Dr. Ebsen Osgood, of the University of Maine at Orono and Dr. Hunter will be examining the reduction of fruit-set as a result of pollinator losses, and the subsequent implications for fruit-eating wildlife.

These projects are part of an ongoing effort to understand the subtle effects of insecticides on the environment as a whole, and on birds in particular. If you would like more information on any of these studies, or reports from past studies, contact the author at the Maine Forest Service, Augusta, ME 04333.

Stephen Oliveri — Environmental Research Coordinator
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Augusta, Maine

Budworms On The Island

Our spies in Newfoundland report that shoot growth of balsam fir was ahead of budworm development in many areas this year. Larval surveys during the spring and early summer showed that high populations and severe defoliation occurred from Highlands River to St. George's River, on the Port au Port Peninsula, near Fox Island River, on Hughes Brook, on the Lower Humber River, on Glide Lake, on Deer Lake, on the southern part of the Baie Verte Peninsula, near King's Point, on Lake Ambrose, on Bay d'Espoir, at the western end of Gander Lake, and in Terra Nova National Park. Generally, the outbreak is less continuous than last year and the severe defoliation was less pronounced. The reddening of foliage was less evident, as trees produced a smaller amount of new foliage after several years of severe budworm attack.

Budworm populations decreased in several areas of the Island, notably in some parts of the Bay of Islands, on the Baie Verte Peninsula, near New Bay Pond, on Exploits Bay, on the northwest and southwest branches of the Gander River, and on the Avalon Peninsula. However, it is alarming that new infestations occurred near River Brook, on Codroy Pond, and in the South Brook valley in western Newfoundland where the trees had just begun to recover from previous damage caused by the budworm. New infestations were also recorded near Marystown on the Burin Peninsula, near Beaver River, and at Goose Point in Labrador.

The wet, humid weather, coupled with highly variable temperatures during larval development, was only partly favorable for the establishment and spread of fungal disease. The assessment of actual percentage of infection has not been completed.

The Provincial Department of Forest Resources and Lands conducted an aerial control program using *Bacillus thuringiensis* and Matacil.® About 250 000 ha (625 000 acres) of fir-spruce forest were treated.

Bibliography Supplement Off The Press

The first supplement to CANUSA's Spruce Budworms Bibliography has been published by the University of Maine, Orono. Released as *Maine Life Sciences and Agriculture Experiment Station Miscellaneous Report No. 255*, the supplement adds 699 new references to the original data base. Because of copyright restrictions, Supplement 1 does not include abstracts. However, citations otherwise resemble those in the first bibliography, and abstracts are available in the computer file.

Supplement 1 was mailed out in October to all current principal investigators and to institutions that received the original bibliography. Eventually the supplement will be availale for purchase from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. No price has yet been set.

Program dollars have paid for the printing of 750 copies of Supplement 1, and most of these have already been mailed out from Maine. If you need a copy and did not receive one, contact the School of Forest Resources, University of Maine, Orono, ME 04473. When their supply runs out, you'll need to order through NTIS at the address above.

Supplements 2 and 3 are on the drawing board, and the program expects to integrate all of them into the original and publish a single volume in the Department of Agriculture's new series "Bibliographies and Literature of Agriculture." This book will be issued from the Washington Office of the Forest Service, probably late in the program.

As a sidelight of the August meeting of CANUSA's Joint Policy and Program Council, Bob Buckman reiterated the Forest Service's position that the bibliography is an extremely valuable and visible output of the program. All entries in the bibliography are part of CORR — the Forest Service data base "Communications on Renewable Resources." Program management is considering how to maintain this data file after the end of CANUSA.

Inventory Update

Issue No. 6 of the *CANUSA Research and Development Management Inventory* was distributed in early October to provide all investigators with up-to-date information for the eastern and western working group meetings. The computer file has been updated by adding all available progress statements and writeups on new studies turned in since Issue No. 5 was distributed last May.

All investigators listed in current studies received indices to the entire file: Activity Index, Investigator/Activity Index, and Investigator Address List. Researchers also received the Basic Record that contains only current studies with significant changes or new studies added since Issue No.5. Through these six inventory issues, any investigator can find out who is doing what in the CANUSA Program.

Patterns of Balsam Fir Mortality Not Due To Budworms

How many of you field troops fighting in the Great Budworm War have noticed wavelike patterns of balsam fir mortality and regeneration on mountain slopes in New England — patterns that do not resemble and, in fact, are not caused by *C. fumiferana*? An interesting article in the January issue of *Science* (Vol. 211, p. 390-393) describes the appearance and causes for this "natural"mortality.

The authors, Douglas Sprugel of Michigan State University and F.H. Bormann of Yale University, explain how wind-induced "waves" of dead trees move slowly across areas of higher-elevation fir stands at about 60-year intervals in regular, predictable cycles. Bands of dead trees, with regeneration underfoot, are followed in succession by young-intermediate trees, then mature trees, then more dead trees. These mortality-regeneration waves can be seen in the Adirondack Mountains of New York, the White Mountains of New Hampshire, and near Mount Katahdin in Maine. Spruce-fir defoliation insects tend to kill fir trees in patches rather than bands, presenting altogether different visual patterns.

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Items From The Press

Budworm infestation described as the greatest in this century — by Edward Clifford — The current spruce budworm infestation in the forests of eastern North America is the largest and most destructive recorded in this century, according to forest researcher E.G. Kettela of Fredericton, N.B.

He told the woodlands section of the Canadian Pulp and Paper Association, meeting in Toronto, that about 28.4 million hectares of fir and spruce forests suffered moderate to severe defoliation in 1980, and that the infestation will continue in 1981 over about 35 million hectares.

Mr. Kettela, an official of the Maritimes Forest Research Centre, said the hardest hit areas are Newfoundland and Cape Breton Island. "Both areas have experienced infestations in the past but these have been short lived. The current infestation is the exception, and extensive damage has been caused to the forests in both regions."

In Ontario, the area of defoliation has increased every year since 1975. And although the area infested in Quebec is on the decrease, this is deceptive because it is the one area that has experienced the most widespread damage.

Mr. Kettela said there has been a decrease in the extent of defoliation in three areas: Maine, New Brunswick and Prince Edward Island, as a result of extensive spraying operations.

Although the largest areas affected are in Ontario and Quebec, the effects are more pronounced in the Atlantic Provinces because of the greater economic reliance on the forests there, he said.

Spruce budworm infestations go in cycles, and the last cycle lasted from 1940 to the early 1960s. The current outbreak started in the late 1960s in three separate areas, northeastern Ontario, western Quebec, and central New Brunswick. "Whatever triggered this infestation did so over a very large area."

Mr. Kettela said the current outbreak "is far from over and has the ability to inflict even more damage on the forests in the years to come."

Louis J. Heit, a Toronto consultant, said the only proven method of protecting forests on a large scale is by aerial spraying of chemical insecticide.

Detrimental effects on aquatic life, birds and animals were traced to the chief spray used, DDT, and its use was discontinued.

Another spray, fenitrothion, was later associated with Reye's Syndrome, a rare disease that affects the brain, liver and other organs, but statistics show the incidence has usually been outside spray areas, and environmentalists now appear less opposed to its use.

(Globe and Mail — March 26, 1981)
Toronto, Ont.

Preliminary results of wood deterioration in stacked wood piles — by G. Warren — Wood storage has been considered as a possible method for preserving insect damaged timber. Due to the susceptibility of damaged balsam fir to secondary insect attack and sapwood degeneration, deterioration and pulping studies have tentatively placed a four to five year salvage limit on dead standing timber for industry use.

The magnitude of the present spruce budworm infestation is such that after considering the pulp and paper and sawmilling industries' quotas, a large volume of dead and moribund timber will extend beyond the salvage limit. Various methods of wood storage have been studied, but stacked wood pile storage at the cutting site is one method which has been poorly researched.

In 1980 a study was begun to investigate deterioration within stacked wood piles. Two study areas were established, one each in central and western Newfoundland. Different sized piles of four and eight foot balsam fir pulpwood were cut and stacked during the spring and fall. Pile size, log size and cutting period were used to determine the effect these factors had upon secondary insect attack and wood deterioration within the pile. Results from these piles would not be available for a couple of years so previously cut and stacked wood piles were located and sampled in order to obtain some preliminary observations.

Several four by eight foot, and tree-length wood piles were located in different areas across the Province. In the four and eight wood piles sample logs were taken, whereas with tree-length piles sample discs were removed. Sapwood deterioration results from these samples were compared with decay statistics from previous tree-length and standing tree deterioration studies.

Sapwood stain and incipient decay have insignificant effects upon pulping properties; however, advanced saprot is responsible for considerable fiber loss during debarking and reduced pulp quality. The most interesting deterioration results were obtained from the four foot wood piles. Within a two year period 17.4 percent of sample four foot log volumes was affected by stain or incipient sapwood defects. After ten years in other piles, 22.7 percent of volume was affected by sapwood defects, of which only 5.9 percent was advanced saprot. Four year old piles showed only 1.7 percent advanced saprot. Four year old eight foot and tree length wood pile samples had 28.3 percent and 56.1 percent volume sapwood defects respectively, of which 17.2 percent and 13.3 percent was advanced saprot. Insect-killed timber exhibited 35.5 percent sapwood defects in merchantable volume of which 11.1 percent was advanced saprot, after standing dead for four years.

Four year old four foot logs showed much less advanced saprot (1.7 percent) than the eight foot logs (17.2 percent), tree length (13.3 percent) and standing dead timber (11.1 percent). In deterioration studies of standing dead timber, rate of wood drying affected saprot development. This same phenomena of rapid drying in shorter bolt lengths may be responsible for the reduced deterioration rate in four foot wood piles.

These study results were preliminary observations from different sets of wood piles scattered across the Province. Most of the four and eight foot wood piles were only one to two cords in size. Continued research on this project will involve sampling of other old piles, especially larger stacked shortwood piles and eventual monitoring of the established study wood piles.

(Woody Points — February, 1981)
Newfoundland Forest Research Centre

Recent Publications

The following publications are now available from the North Central Forest Experiment Station, USDA Forest Service, 1992 Folwell Ave., St. Paul, MN 55108:

Gary J. Brand. 1981. "GROW" — a computer subroutine that projects the growth of trees in the Lake States' forests. USDA Forest Service, Research Paper NC-207.

Gary J. Brand. 1981. "Simulating timber management in Lake States' forests." USDA Forest Service, General Technical Report GTR-69.

Dennis L. Murphy. 1981. "An evaluation of database management system application to forest inventory data." USDA Forest Service, General Technical Report NC-67.

A new publication is available from the Midwest. It is by W.H. Carmean and Jerold T. Hahn and it is titled "Revised site index curves for balsam fir and white spruce in the Lake States." The original site index curves (the announcement mentions) are revised from a breast height age to a total age basis. Formulations are included for estimating site index by using computers or programmable, hand-held calculators. The catalogue number is Research Note NC-269 and copies may be obtained from the North Central Forest Experiment Station, USDA Forest Service, 1992 Folwell Ave., St. Paul, MN 55108.

The following report is available from Forest Pest Management, State and Private Forestry, USDA Forest Service, Southwestern Region, 517 Gold Ave. S.W., Albuquerque, NM 87102:

N. William Wulf and T. J. Rogers. 1981. "Western spruce budworm silvicultural demonstration area project, Carson National Forest." Southwestern Region, Report No. 1.

This publication may be ordered from the Pacific Northwest Forest and Range Experiment Station, 809 NE 6th Ave., Portland, OR 97232:

Robert O. Curtis, Gary W. Clendenen, and Donald J. DeMars. 1981. "A new stand simulator for coast Douglas-fir. DSIM user's guide." USDA Forest Service, General Technical Report PNW-128.

The hazard-rating symposium proceedings, mentioned in Newsletter No. 16, are now available from the USDA Forest Service, P.O. Box 2417, Washington, DC 20013. Several CANUSA investigators contributed to this publication:

R. L. Hedden, S. J. Barras, and J. E. Coster, technical coordinators, 1981."Hazard-rating systems in forest insect pest management: symposium proceedings." (July 31-Aug. 1, 1980, Athens,Ga.) USDA Forest Service, General Technical Report WO-27.

The April-May 1981 issue of *Timber Producers Bulletin* carried the following article by Steve Sinclair, Bob Govett, and Jim Bowyer: "Potential lumber grade yields from balsam fir and spruce budworm killed balsam fir", p. 10-11.

The Forest Pest Management Institute of the Canadian Forestry Service, P.O. Box 490, Sault Ste. Marie, Ont. P6A 5M7 has recently issued two publications. They are:

P.D. Kingsbury and B.B. McLeod. 1981. "Fenitrothion and forest avifauna studies on the effects of high dosage applications." Report FPM-X-43.

S.B. Holmes, R.L. Millikin, and P.D. Kingsbury. 1981. "Environmental effects of a split application of Sevin-2-Oil." Report FPM-X-46.

There is news of two recent publications from the Maritimes Forest Research Centre, Canadian Forestry Service, P.O. Box 400, Fredericton, N.B. E3B 5P7. They are:

C.C. Smith, W.R. Newell, and T.R. Renault. 1981. "Common insects and diseases of balsam fir Christmas trees." Publication 1328 (Revised). This is also available in French.

C.A. Miller and T.R. Renault. 1981. "The use of experimental populations to assess budworm larval mortality at low densities." Information Report M-X-115.